SEE Question Bank 2025

Course title: NUCLEAR AND PARTICLE PHYSICS **Course Code: M24SP0302**

Unit-I:

1. With a neat graph show that nuclear forces are short range forces. [Marks 10]
2. Describe Bohr formula for the energy loss of a heavy charged particle moving through matter. [Marks 10] or
3. Derive the formula for stopping power (loss of energy per unit length) of a charged particle passing through matter. [Marks 10]
4. With example and clear graph explain Bohr's independence hypothesis of compound nucleus. [Marks 10]
5. Explain the following terms (i) linear absorption coefficient (ii) mass absorption coefficient (iii) atomic absorption cross-section (iv) nuclear binding energy and (v) compound nucleus. [Marks 10]
6. Discuss and derive the expression for intensity of gamma-rays passing through a thin plate of thickness *x*. [Marks 10]
7. Explain the following characteristics of nuclear forces (i) short range, (ii) saturation, (iii) charge independence and (iv) exchange character. [Marks 10]
8. Write a note on differential cross section of a nuclear reaction. [Marks 10]
9. Discuss interaction of gamma-rays with matter with special reference to photoelectric absorption. [Marks 10]

10. Write a short note on Bremsstrahlung radiation. [Marks 5]
11. Write a short note on nuclear mass defect. [5 Marks]
12. Write a short note on binding energy of nucleus. [5 marks]
13. Find the Q-value of a reaction $_7N^{14}(\alpha, p)\ _8O^{17}$. Given mass of $\alpha = 4.0026$ amu, mass of $_7N^{14} = 14.0031$ amu, mass of $_8O^{17} = 16.9994$ amu, mass of p = 1.0078 amu and 1 amu = 931 MeV. [Marks 5]
14. Find the threshold energy of the reaction $_7N^{14}(\alpha, p)\ _8O^{17}$. Given mass of $_7N^{14} = 14.00307$ amu, mass of $_8O^{17} = 16.99913$ amu, mass of $\alpha = 4.00260$ amu, mass of p = 1.00782 amu. [Marks 5]
15. Calculate the binding energy of deuterium ($_1H^2$) if the masses of proton, neutron and deuterium nucleus are 1.007826 amu, 1.008665 amu, and 2.013553 amu, respectively. [5 marks]
16. Consider the following induced fission reaction, $^{235}U_{92} + n \rightarrow {}^{93}Rb_{37} + {}^{141}Cs_{55} + 2n$

Where neutron momenta in both initial and final states are negligible. Calculate the ratio of the kinetic energies of the daughter nuclei, KE($^{93}Rb_{37}$) /KE ($^{141}Cs_{55}$). [5 marks]

Unit-II:

1. Write a short note on (i) nuclear fusion and (ii) nuclear fission. [Marks 10]
2. Discuss principle, construction and working of Li-ion drifted nuclear radiation detector. [Marks 10] or

3. Draw the diagram of scintillation counter and explain the significance of its each part. [Marks 10]
4. Discuss the principle, construction and working of scintillation counter. [Marks 10]
5. What is cyclotron? Explain its working with neat construction diagram. [Marks 10]
6. What is LINAC? Discuss principle, construction, and working of LINAC. [Marks 10]
7. Write a short note on (i) semiconductor radiation detectors and (ii) particle accelerators. [Marks 10]
8. Explain the working mechanism of NaI(Tl) scintillation detector. [Marks 10]

9. Discuss the principle, construction and working of synchrotron. [Marks 10]
10. Why is lithium used to make Li-ion drifted nuclear radiation detector? [Marks 5]
11. What are particle accelerators? Why do we need to accelerate the charged particles? [Marks 5]
12. Estimate the energy released in nuclear fission based on liquid drop model. [Marks 5]
13. The capacitance of a silicon radiation detector is 318×10^{-12} F. What potential must be developed across this capacitance by the absorption of 4.5 MeV alpha-particles which produces one ion pair for each 3.5 eV. [Marks 5]
14. A cyclotron has an oscillator frequency of 12 MHz and a dee radius of 0.55 m. It is used to accelerate deutrons, mass of deutron = 3.34×10^{-27} kg. If the magnetic flux density is 1.57 T, calculate the energy to which deutrons are accelerated. [Marks 5]
15. A linear charged particle accelerator is driven by an alternating voltage source operating at 10MHz. Assume that it is used to accelerate electrons. After a few drift tubes the electrons attain a velocity of 2.9×10^9 m/s. Calculate the minimum length of each drift tube in meter, to accelerate the electrons further. [5 marks]

Unit-III

1. Discuss the basic similarities between a drop of liquid and atomic nucleus. [10 marks]
2. Elucidate the contribution of surface energy and asymmetry energy term to calculate the Semi-empirical binding energy formula of nucleus. [10 marks]
3. What is Fermi gas model? Mention and explain the assumptions of this model. [10 Marks]
4. Mention the basic assumptions of nuclear shell model. [5 Marks]
5. How does the shell model account for the existence of magic numbers? Obtain a schematic energy-level diagram up to magic number 28. [Marks 10]
6. Discuss the assumptions of Fermi's theory of beta decay. [10 marks]
7. With a clear graph, explain the potential depth profile of neutron and proton. [5 marks]
8. Elucidate the concept of Kurie plots. [5 marks]
9. Calculate the spin parity of $_6C^{12}$ and $_5B^{10}$. [10 marks]
10. Whether the following beta decay, $_1H^3 \rightarrow {}_2He^3 + e^- + \bar{\nu}$ is allowed or not by Fermi and Gammow Teller selection rules? [Marks 5]
11. Explain the concept of multipolarity of gamma rays. [5 marks]
12. Write a short note on internal conversion process. [5 marks]

Unit-IV

1. Using Wu experiment explain the parity violation in week interactions. [Marks 10] or
2. Parity symmetry is violated in week interactions, explain with example. [Marks 10]
3. Discuss the basic types of interactions in nature with special reference to elementary particles. [Marks 10]
4. Discuss the color degree of freedom for quarks. [Marks 10]
5. Explain the concept of parity operation considering quantum and classical systems. [Marks 10]
6. Explain with examples the law of conservation of lepton, baryon and strangeness for elementary particles. [Marks 10]
7. Explain in detail the concept of quark model. [Marks 10]
8. Discuss the properties of quarks and anti-quarks. [Marks 10]
9. Write short notes on (i) Charge conjugation symmetry, and (ii) Lepton family. [Marks 10]

10. What do you mean by parity? With example explain parity symmetry. [Marks 5]
11. Mention the properties of quarks. [Marks 5]
12. Why is proton made up of *uud* quarks?
13. Verify the conservation of charge, Baryon number, z-component of Iso-spin and strangeness for the following interaction, p + $\bar{p} \rightarrow 2\pi^+ + 2\pi^- + 2\pi^0$. [Marks 5]
14. Identify the unknown particle X in the following nuclear reaction, p + p $\rightarrow \pi^+ + n + \Lambda^0 + X$. [Marks 5]
15. Show that the decay, $\Sigma^+ \rightarrow p^+ + \pi^0$ by strong or electromagnetic interaction is forbidden. [Marks 5]
16. Explain the concept of parity symmetry. [5 marks]